I) YNAMIC MODELLING AND SIMULATION STUDY FOR THE G ALILEO SPACECRAFT PULSED-MODE SPINUP/400 N MAIN ENGINE BURN/SPINDOWN MANEUVERS

Che-Hang Charles Ih and Elihu H. McMahon, II

Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109
USA

The dual-spin Galileo spacecraft (Fig. 1) was launched on October 18, 1989. As of December 7, 1995, it was successfull y inserted into Jupiter's orbit and began its 23-month exploration of the planet and its moons. Normally, the spacecraft spins at 2.9 rpm. For critical events such as atmospheric probe release and 400 N main engine firing, the spacecraft is required to spin up to 10.5 rpm to enhance gyroscopic stability, avoid propellant unporting, and preserve science/magn etometer boom integrity. Since test results of the Retro Propulsion Module Team showed that prolonged continuous firing of the spin thrusters is not acceptable, spinup/spindown maneuver has to be done in pulsed mode. Examinat ion of the dynamic interaction among the spin thruster pulsing frequency, scicncc/magnetometer boom flexible modes, and the propellant slosh modes was mandatory to ensure the science/magnetometer boom structural integrity and to avoid cat astrophic propel I ant unporting.

To this end, a 7-body Galileo model was developed. It consisted of a base body (stator, dry rotor, and scan platform), four propellant slugs, science boom, and magnetometer boom (with a 3 degrees-of-freedom spring connecting the two booms). The modal properties of the science/magn etometer boom modes up to 2.21 Iz were reproduced accurate] y by this mass-spring model. Movements of the propellant slugs can be realized by two rotations of the imaginary link connecting the slug and the tank center. Thrusts arc represented as forces and torques. SD-EXACT was used to generate equations of motion, calculate angular momentum and kinetic energy, etc. The main program was written in ACSL and subroutines were written in FORTRAN.

The complete spinup/400 N engine burn/spindown maneuver sequence has been simulated for the critical events of Orbit Deflection Maneuver (ODM), Jupiter Orbit Insertion (JOI), and Perijove Raise Maneuver (PRM). The prediction of safe ODM and JOI was validated in flight. For PRM, however, the simulation results showed that although the science/magnetometer boom structural i ntegrit y is ensured, propellant report ing will occur (due to low propellant level) if the current spin thruster duty cycle (1.3 scc ON / 3.9 sec OFF) remains unchanged. A group of ncw duty cycles which correspond to thruster pulsing frequencies that are higher than the propellant slosh frequency range were then proposed. Simulation results demonstrated that propellant unporting problem can be avoided if any of these duty cycles is used. The project management has selected the proposed 0.9 sec ON / 0.9 scc OFF duty cycle for PRM scheduled to be executed on March 14, 1996.

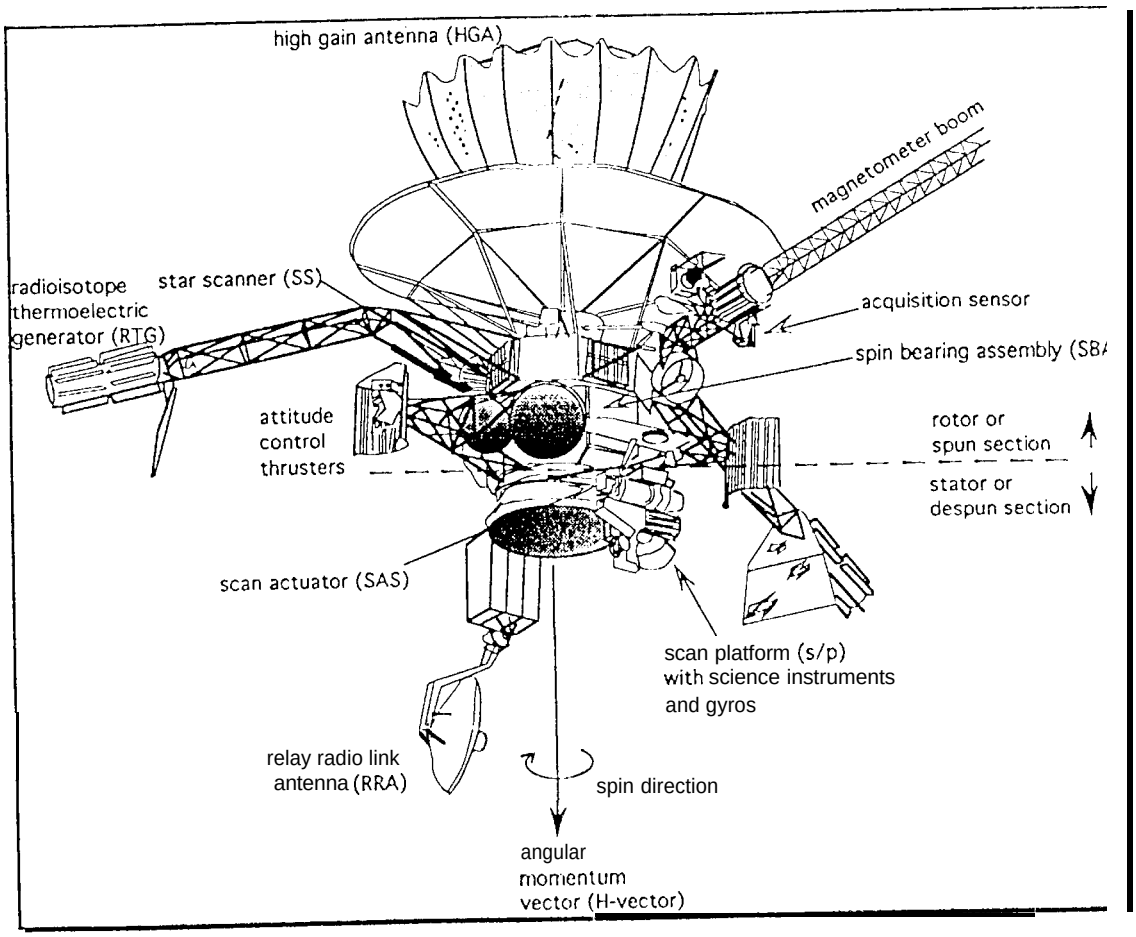

Figure 1. Galileo Spacecraft